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Life form diversity and biological spectrum of plants along an elevation gradient in Mount Abune-Yosef, Ethiopia

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Key words: Afro-alpine, Biological spectrum, Raunkiaer, Chamaephytes and therophytes

Abstract

The aim of this study was to classify plant functional types based on life forms adaptation in Afro-alpine ecosystem. A total of 31 plots were established along altitudinal gradients of Afro-alpine area within the range of 3830m.a.s.l to 4168m.a.s.l. The data were recorded in 5m × 5m quadrats based on homogeneity. Physiographic variables such as altitude and longitude were measured for each quadrat using GPS. Information on habit, habitat, and the position of perennating buds were recorded so as to draw a biological spectrum, following the concept of Raunkiaer. A total of 107 plant species belonging to 76 genera, and 30 families were identified and documented. The dominant families were Asteraceae, followed by Caryophyllaceae, Scrophulariaceae, Lamiaceae, Crassulaceae, Brassicacea and Ranunculaceae. The family Asteraceae was represented by all the five major life form groups. The dominant life form was Chamaephytes represented by 39 species (36%) followed by Therophytes, 21 species (20%), Geophytes, 16 species (15%), Hemicryptophytes, 19 species (18%) and Phanerophytes 12 species (11%). The Chi-square test showed significant differences between the Raunkiaer's spectrums (χ^2= 129.85, p < 0.001) to sub-afroalpine and afroalpine flora. Chamaephytes were with highest individual values (83.4%) and show high deviation from the Raunkiaers spectrum. The finding confirmed that the studied area was characterised by the two dominated life forms, the Chamaephytes and Therophytes, therefore the mount Abune-Yosef is characterised as Chamaeo-Therophytic. Both Chamaephytes and Therophytes are characterized the colder and high altitude.

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Introduction

The geological structure of Ethiopia is a massive highland complex of volcanic mountains with the highest peak up to 4533m.a.s.l (RasDashen) and plateaus divided by an extensive fault system of the Great Rift Valley, and surrounded by lowland of Afar depression that measure around 126m below sea level (Asfawossen *et al.*, 2008). This topography has determined diverse climatic conditions that have given rise to a great variety of ecologically distinct regions (Institute of Biodiversity Conservation, 2009) which are considered as regions of high endemism and biodiversity (Mittermeier *et al.*, 2004).The Ethiopian highlands constitute the largest continuous highland system in the African continent, accounting for 50% of all the land above 2000 meters and 80% of all the land above 3000 meters (Tamrat, 1993, Largen and Spawls, 2010).

A life form is characterized by plant adaptation to certain ecological conditions (Mera *et al.*, 1999) and is an important physiognomic attribute that has been widely used in vegetation studies. Life form indicates micro and macroclimate (Shimwell, 1971) as well as human disturbance of a particular area (Cain and Castro, 1959, Smart *et al.*, 2005, Mistire *et al.*, 2015). Excessive utilization of plant resources and overgrazing has resulted in change in the life form composition of plant communities (Verma and Shukla, 1993, Reddy *et al.*, 2002). Zonal plant formations (afroalpine ecosystems like Abune-Yosef Massif) are characterized by the abundance of a specific life form, irrespective of the taxa present, in a large region of an area (Sharma *et al.*, 2014).

The life form classification is an important physiognomic attribute that expresses the harmony between plant and its surroundings. So, it is used in vegetation studies, ranking next to floristic composition (Shimwell, 1971). Different systems of classification and description of plant life forms have been developed by many ecologists (Sharma *et al.*, 2014). Of these the Raunkiaer (1934) system is the most popular with global acceptance. It is mainly based on the position, degree of protection of the renewing buds, which are more protected during unfavorable seasons and assumes growth when the seasons become favorable (Abusaief and Dakhil, 2013). According to this system, plant species can be grouped into five main classes: phanerophytes, chamaephytes, hemicryptophytes, cryptophytes and therophytes.

The percentage distribution of various life form classes is termed as the biological spectrum (Raunkiaer, 1934), which is an index for comparison of plant communities that are widely separated geographically. It indicates biotic interaction, habitat and climate deterioration and is used to express the percent distribution of life forms of a given flora (Raina and Sharma, 2010, Gazel and Raina, 2015). In different regions of the globe, occurrences of similar biological spectrum indicate similar environmental conditions as well as micro and macro climate which govern over the area (Raunkiaer, 1934, Carvalho da Costa *et al.*, 2007, Nazir *et al.*, 2014, Hussain *et al.*, 2015, Abedi and Abedi, 2015).

The plant species richness of Mount Abune-Yosef has been studied by Kiflay *et al.* (2019). However, there has not been a study of plant functional types based on life forms and Biological spectrum of the species in the mountain. Hence, it was important to conduct such a study focusing on the aspects of life forms and the biological spectrum of the area to provide baseline scientific information. Such comprehensive ecological study is very useful for the purposes of protection, reclamation and management of biodiversity in the study area. The present study aims to investigate the life form diversity and biological spectrum along altitudinal gradients in Mount Abune-Yosef. The study addresses the following questions, 1) which classes characterize the mountain life form and biological spectrum 2) Is the biological spectrum in Mount Abune-Yosef significantly different from Raunkiaer's normal spectrum?

Material and method

Abune-Yosef Community Conservation area

Abune-Yosef is a prominent mountain near the eastern escarpment of the Ethiopian Highlands, located in the Lasta massif of North Wollo Zone of Amhara Region, between 12°8′7″N and 39°15′7″E (Fig. 1). The Abune-Yosef Mountain reaches up to 4260 m.a.s.l. (13,976 ft) and covering 70km² of Afro-alpine habitat (Richman and Biniyam 2013). The Afro-alpine ecosystem has been reduced over the last decades, as in most of Ethiopian highlands, and it currently remains above 3,700m.a.s.l only (Saavedra, 2009).

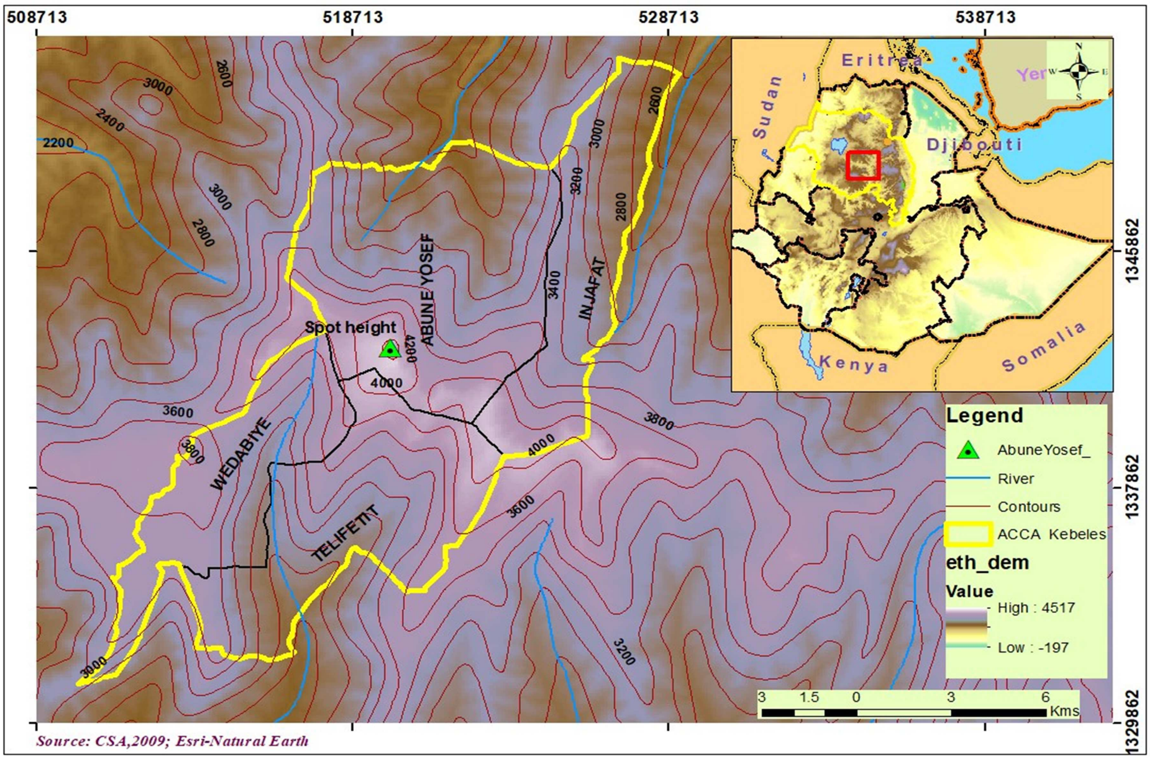

Fig. 1. Map of Mount Abune-Yosef Community Conservation Area (ACCA).

The climate is moist and cold, with a wet season from June to October, and a dry season from November to May. The average annual rainfall is 2,000mm and the mean annual temperature ranges between 7.5 and 11°C (Environmental Support project, 2001).

Abune-Yosef Afro-alpine area has tourism value due to its scenery and the presence of endemic animals and plants which attract a growing number of visitors. Besides, area has been serving as an important religious site for centuries with many churches and monasteries around (Saavedra, 2009).

The Afro-alpine mountain system is characterized by large variation of temperature during the day and the night times, that means, "summer every day and winter every night" (Hedberg, 1970). Besides, the Afro-alpine ecosystems are also identified by harsh climatic conditions such as low temperature, high solar radiation and strong wind (White, 1983). The Afro-alpine landscape is open and dominated by grasslands and heath lands, with steep slopes covered by rocky and shallow soils, valleys and depressions, with deep black soils, sustaining an important for the presence of various plant life forms.

The mosaic of Afro-alpine vegetation types includes "guassa' grasslands (*Festuca simensis*), giant lobelias (*Lobelia rhynchopetalum*), *Euryops pinifolius* bushes locally known as "chifra", "kirshiba," or "charranfe", and remnant patches of *Erica arborea* (Fig. 2).

The Abune-Yosef Mountain designated as community conservation area by regional government in 2016 since it is a home of endemic species of five plants, eight mammals and six birds and endangered species of seven mammals and nine birds.

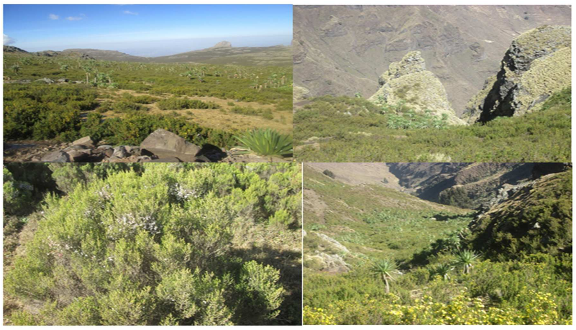

Fig. 2. Collective view of Mount Abune-Yosef Afro-alpine Vegetation.

Sampling design and data collection

The data collections were carried out in Mount Abune-Yosef between 23rd January 2016 and 9th April 2018. Life form data were collected from four transects lines, which were systematically laid relative to altitudinal variation (3830 to 4168m.a.s.l) and vegetation coverage of the area within 400m interval apart from each other. Along each transect, 6 to 8 quadrats (size = 5m × 5m each) were laid at 50m interval. About 31 sample quadrats were laid in the Mountain (Fig. 3). Through the recording; Homogeneity, physiographic variables including altitude and longitude were measured for each quadrat. GPS readings were recorded for starting permanent plots for seasonal follow up twice in a year (in the beginning and ending of dry and wet season).

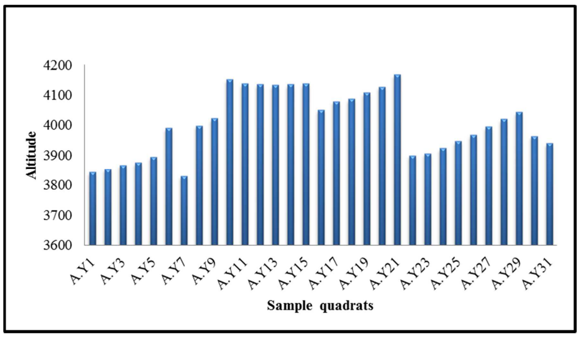

Fig. 3. Altitudinal distribution of Sample Quadrat at Mount Abune-Yosef.

Information on habit, habitat, vegetation type, nature and position of perennating buds was recorded in order to draw a biological spectrum, following the concept of Raunkiaer (1934). For determination of life form, observations were made on position of perennating buds during unfavorable (dry) condition.

All vascular plant species, climbers, trees, and shrubs were classified as Phanerophytes, Hemicryptophytes, Chamaephytes, Geophytes and Therophytes according to main life form groups of Raunkiaer. Specimens of all vascular plant taxa were collected, pressed, dried and brought to the National Herbarium (ETH), Addis Ababa University for identification and preservation. The specimens were dried in a dryer, kept in a deep freezer for 72 hours and identified referring to the volumes of Flora of Ethiopia and Eritrea as well as by comparing with the preserved specimens at the Herbarium and finally documented.

Data Analysis

After identification, the flora was classified into different life form classes following Raunkiaer (1934), Mueller-Dombois and Ellenberg (1974) and Hussain (1989). Simple metrics was used to analyze proportions of life forms (Pharswan *et al.*, 2010) and the percentage life form is calculated as follows:

$$\% \text{ Life form} = \frac{\text{Number of species in any life form}}{\text{Total number of species of all life forms}} \times 100$$

Chi-square ($\chi 2$) test was used, following the method in Zar (1999) to verify whether the life form spectrum was significantly different from the expected according to the Raunkiaer's normal spectrum. If there were significant differences, the contribution percentage of each class in the chi-square values was calculated. The following formula for Chi-square test was applied:

$$\chi 2 = \sum (O - E)^2/E$$

Where O is the observed values, E is the expected values and the sigma sign means that everything that follows is summed.

Result

Life form Composition

The analysis of the life form composition of Mount Abune-Yosef indicates high proportion of Chamaephytes (36%) followed by Therophytes (20%), Hemicryptophytes (18%), Phanerophytes (11%) and Geophytes (15%). The percentage of species belonging to each life form category relative to the total number of species is presented in (Fig. 4).

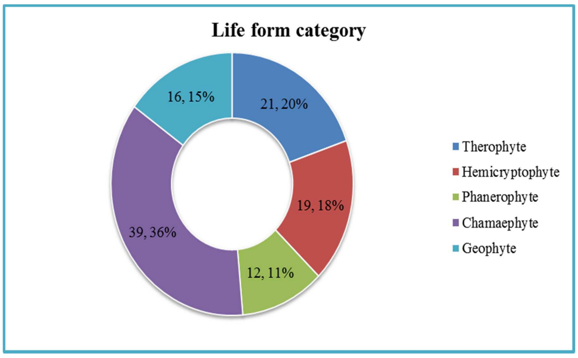

Fig. 4. Properties of life form category of Mount Abune-Yosef.

Floristic contribution

A total of 107 plant species belonging to 76 genera, and 30 families were collected from Mount Abune-Yosef (Fig. 5). Nineteen species (17.76%) are endemic to Ethiopia.

The dominant families were Asteraceae, followed by Caryophyllaceae, Scrophulariaceae, Lamiaceae, Crassulaceae, Brassicaceae and Ranunculaceae (Appendex1). The family Asteraceae was represented by all the five major life form groups.

Appendix 1. Lists of vascular plant with their family and life form category.

Species Name	Family	Origin	Life Form
Aeonium leucoblepharum A. Rich.	Crassulaceae		Chamaephyte
Agrocharis melanantha Hochst.	Apiaceae		Therophyte
Alchemilla abyssinica Fresen.	Rosaceae		Hemicryptophyte
Alchemilla kiwuensis Engl.	Rosaceae		Hemicryptophyte
Alchemilla pedata A. Rich.	Rosaceae		Hemicryptophyte
Andropogon distachyos L.	Poaceae		Hemicryptophyte
Anthemis tigreensis J.Gayex.A.Rich.	Asteraceae		Therophyte
Arabis alpina L.	Brassicaceae		Hemicryptophyte
Arabis thaliana L.	Brassicaceae		Therophyte
Artemisia abyssinica Sch. Bip. Ex A.Rich.	Asteraceae		Phanerophyte
Artemisia schimperi Sch.Bip. ex Engl.	Asteraceae	Endemic	Hemicryptophyte
Asplenium abyssinicum Fee	Aspleniaceae		Chamaephyte
Asplenium aethiopicum (Burm.f.) Bech.	Aspleniaceae		Chamaephyte
Berula erecta (Hudson) Coville	Apiaceae		Chamaephyte
Bidens macroptera (Sch.-Bip. ex Chiov.) Mesfin	Asteraceae	Endemic	Therophyte
Brachypodium sylvaticum (Huds.) P. Beauv.	Poaceae		Therophyte
Campanula edulis Forssk.	Campanulaceae		Hemicryptophyte
Cardamine hirsuta L.	Brassicaceae		Chamaephyte
Carduus macracanthus Sch. Bip. ex. Kazmi	Asteraceae	Endemic	Chamaephyte
Carex peregrina Link	Cyperaceae		Chamaephyte
Cerastium octandrum A. Rich. Var. *octandrum*	Caryophyllaceae		Therophyte
Cineraria sebaldii Cufod.	Asteraceae	Endemic	Chamaephyte
Clematis simensis Fresen.	Ranunculaceae		Phanerophyte
Conyza stricta Willd.	Asteraceae		Therophyte
Crassula granvikii Mildbr.	Crassulaceae		Therophyte
Crassula schimperi Fisch. & Mey.	Crassulaceae		Chamaephyte
Cynoglossum coeruleum Hochst. ex A.DC.	Boraginaceae	Endemic	Therophyte
Delosperma abyssinica (Regel) Schwantes	Aizoaceae		Geophyte
Delosperma schimperi (Engl.) H.E.K. Hartmann &Niesler	Aizoaceae		Geophyte
Dianthoseris schimperi Sch.Bip.ex A. Rich.	Asteraceae		Geophyte
Dichrocephala chrysanthemifolia (Bl.) DC.	Asteraceae		Therophyte
Dichrocephala integrifolia (L. f.) O. Kuntze	Asteraceae		Therophyte
Discopodium penninervium Hochst.	Solanaceae		Phanerophyte
Epilobium hirsutum L.	Onagraceae		Hemicryptophyte
Epilobium salignum Hausskn.	Onagraceae		Hemicryptophyte
Epilobium stereophyllum Fresen.	Onagraceae		Hemicryptophyte
Erica arborea L.	Ericaceae		Phanerophyte
Erophila verna subsp. *macrosperma* (Sebald) Jonsell	Brassicaceae		Chamaephyte
Erucastrum meruense Jonsell	Brassicaceae		Therophyte
Euryops pinifolius A. Rich.	Asteraceae	Endemic	Phanerophyte
Festuca simensis Hochst ex. A. Rich.	Poaceae		Chamaephyte
Galium aparinoides Forssk.	Rubiaceae		Therophyte
Galium simense Fresen.	Rubiaceae		Therophyte
Geranium arabicum Forssk.	Geraniaceae		Hemicryptophyte
Gnaphalium unionis Sch. Bip. ex Oliv. & Hiern	Asteraceae		Chamaephyte
Haplocarpha rueppelii (Sch. Bip.) Beauv.	Asteraceae		Chamaephyte

Species Name	Family	Origin	Life Form
Haplocarpha schimperi (Sch. Bip.) Beauv.	Asteraceae		Chamaephyte
Haplosciadium abyssinicum Hochst.	Apiaceae		Geophyte
Hebenstretia angolensis Rolfe	Scrophulariaceae		Therophyte
Helichrysum citrispinum Del.	Asteraceae		Chamaephyte
Helichrysum formosissimum Sch. Bip. ex A. Rich.	Asteraceae		Chamaephyte
Helichrysum quartinianum A. Rich.	Asteraceae		Chamaephyte
Helichrysum splendidum (Thunb.) Less.	Asteraceae		Chamaephyte
Hypagophytum abyssinicum (A. Rich). Berger	Crassulaceae		Chamaephyte
Hypericum revolutum Vahl,	Hypericaceae		Phanerophyte
Inula confertiflora A. Rich.	Asteraceae	Endemic	Phanerophyte
Kniphofia foliosa Hochst.	Asphodelaceae	Endemic	Geophyte
Launaea rueppellii (Sch.Bip.ex Oliv. & Hiern) L. Boulos.	Asteraceae		Geophyte
Lobelia rhynchopetalum Hemsl.	Lobeliaceae	Endemic	Phanerophyte
Malva verticillata L.	Malvaceae		Therophyte
Minuartia filifolia (Forssk.) Mattf.	Caryophyllaceae		Chamaephyte
Misopates orontium (L.) Raf.subsp. *Gibbosum* (Wall.) D.A.Sutton	Scrophulariaceae		Chamaephyte
Myosotis vestergrenii Stroch	Boraginaceae		Geophyte
Nepeta azurea R. Br. ex Benth.	Lamiaceae		Chamaephyte
Oreophyton falcatum (A.Rich) O.E. Schulz	Brassicaceae		Geophyte
Phagnalon abyssinicum Sch. Bip. ex A. Rich.	Asteraceae	Endemic	Chamaephyte
Polypogon monspeliensis (L.) Desf.	Poaceae		Chamaephyte
Primula verticillata Forssk.	Primulaceae	Endemic	Hemicryptophyte
Ranunculus multifidus Forssk.	Ranunculaceae		Chamaeophyte
Ranunculus oreophytus Del.	Ranunculaceae		Geophyte
Ranunculus stagnalis Hochst. ex A. Rich.	Ranunculaceae		Geophyte
Ranunculus tembensis Fresen.	Ranunculaceae		Geophyte
Rhabdotosperma scrophulariifolia (Hochst. ex A. Rich.)Hartl	Scrophulariaceae		Chamaephyte
Rosa abyssincia Lindley.	Rosaceae		Phanerophyte
Rumex abyssinicus Jacq.	Polygonaceae		Phanerophyte
Rumex nervosus Vahl	Polygonaceae		Phanerophyte
Sagina abyssinica A. Rich.	Caryophyllaceae	Endemic	Geophyte
Sagina afroalpina Hedberg	Caryophyllaceae		Therophyte
Salvia merjamie Forssk.	Lamiaceae		Chamaephyte
Satureja imbricata (Forssk.) Briq.	Lamiaceae		Hemicryptophyte
Satureja paradoxa (Vatke) Engl.ex Seybold	Lamiaceae	Endemic	Hemicryptophyte
Satureja punctata (Benth.) Briq., subsp.Ovata (Benth.) Seybold	Lamiaceae	Endemic	Hemicryptophyte
Scabiosa columbaria L.	Dipsacaceae		Chamaephyte
Sedum crassularia Raym.-Hamet	Crassulaceae		Chamaephyte
Senecio farinaceus Sch. Bip. ex A. Rich.	Asteraceae	Endemic	Chamaephyte
Senecio inornatus DC.	Asteraceae		Chamaephyte
Senecio nanus Sch. Bip. ex A. Rich.	Asteraceae	Endemic	Geophyte
Senecio steudelii Sch. Bip. ex A. Rich	Asteraceae	Endemic	Chamaephyte
Silene macrosolen A. Rich.	Caryophyllaceae		Geophyte
Solanecio gigas (Vatke) C. Jeffrey	Asteraceae	Endemic	Phanerophyte
Spergularia media (L.) J. & C. Presl.	Caryophyllaceae		Geophyte
Spergularia rubra (L.) J. & C. Persl.	Caryophyllaceae		Therophyte
Stellaria media (L.) Vill.	Caryophyllaceae		Therophyte
Swertia abyssinica Hochst.	Gentianaceae		Chamaephyte
Swertia schimperi (Hochst.) Griseb.	Gentianaceae		Chamaephyte
Swertia volkensii Gilg	Gentianaceae		Chamaephyte
Swertia welwitschii Engl.	Gentianaceae		Hemicryptophyte
Thymus schimperi Ronniger	Lamiaceae	Endemic	Chamaephyte
Trifolium acaule Steud. ex A. Rich.	Fabaceae		Chamaephyte
Umbilicus botryoides A. Rich.	Crassulaceae		Geophyte
Urtica simensis Steudel	Urticaceae	Endemic	Therophyte
Verbascum arbusculum (A. Rich.) Hub.-Mor.	Scrophulariaceae		Therophyte
Veronica abyssinica Fres.	Scrophulariaceae		Hemicryptophyte
Veronica glandulosa Hochst. ex Benth.	Scrophulariaceae		Hemicryptophyte
Veronica gunae Schweinf. ex Fries	Scrophulariaceae		Hemicryptophyte
Veronica simensis Fres.	Scrophulariaceae		Hemicryptophyte
Vulpia bromoides (L.) S.F. Gray	Poaceae		Hemicryptophyte

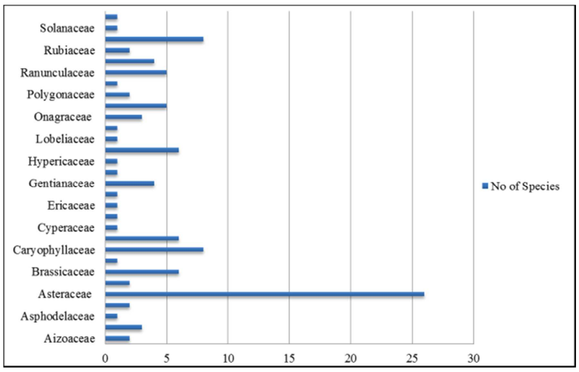

Fig. 5. Species distribution and abundance with the respective families in Mount Abune-Yosef.

Relative biological spectrum

Based on the result from Chi-square test ($\chi2$) test, life form spectrum of the Abune-Yosef community conservation area showed significant differences to that of the Raunkiaer's spectrums ($\chi2$= 129.85, p < 0.001). Chamaephytes showed significant deviation from the Raunkiaers spectrum (Table 1) having the highest individual value (83.4%).

Table 1. Comparison of Life form spectrum.

Study area and Raunkiaer normal Spectrum	PH	CH	H	Cr (Ge)	TH	Total
Abune-Yosef	11	36	18	15	20	100
Raunkiaer normal spectrum	46	9	26	6	13	100
$\chi2$	26.3	83.4	2.7	14.1	3.35	129.85

Ph = Phanerophytes, Ch = Chamaephytes, H = Hemicryptophytes, Cr = Cryptophytes (Geophytes), Th = Therophytes

Discussion

Life form Composition

The study finding indicates that Chamephytes were more dominant than other life forms in the mount Abune-Yosef Afro-alpine area. The finding of Heitschmidt and Stuth (1991) indicates that Chamaephytes become more prominent in subalpine zones due to soil and climatic conditions which also support the present study indicates alpine vegetation dominated with chamaephytes. Another finding (Muhammad, 2012) also stated that Chamaephytes are indicators of alpine vegetation. Cold conditions, low temperature, wind and biotic factors result in unfavorable conditions paving way for chamaephytes (Amjad *et al.*, 2012). These may due to characterization of great variations of temperature during the day and night in Afro-alpine area. The Afro-alpine mountain systems is characterized by large variation of temperature during the day and the night, that is, "summer every day and winter every night" (Hedberg, 1970).

Most landscape in the Ethiopian highlands have been influenced by farming, grazing, firewood collection and grass cutting over several centuries (Zelalem *et al.*, 2012). Shahid and Joshi (2018) indicated the predominance of Therophytes in disturbed areas. The presence of high amount of Therophytic life form next to Chamaephytes indicated that the studied Afro-alpine area is influenced by enormous anthropogenic disturbance like road construction, grazing and farming up to highest altitude (3780m.a.l.s) and proximity of settlement to the Afro-alpine area. This reason may be facilitating the dominance of Therophyte over the other life forms in Mount Abune-Yosef Community conservation areas. In addition to the above mentioned factors, Therophytes are usually dominated in some of the driest and coldest environments of the world (Harrison *et al.*, 2010) due to their shortest life cycle.

Because of the occurrences of the two dominant life forms, Chamaephytes and Therophytes, the finding of the studied Afro-alpine areas is named by both dominant life forms. According to the biological spectrum given by Raunkiaer (1934), the flora of the present study areas might be named as Chamae-therophytic. Qadir and Shetvy (1986) considered Chamaephytes and Therophytes as the major life forms under unfavorable environmental regions.

Hemicryptophytes contributed lower share relative to normal Raunkiaer (1934) life form spectrum. This may be due to the absences of sufficient moisture to support the growth of this Hemicryptophytic life form. This finding agrees with the report of Mahdavi *et al.* (2013) and Mistire *et al.* (2015) who reported that a strong relation between moisture in the upper soil layers and Hemicryptophytes prevalence.

Geophytes were also exceeding the expected normal life form spectrum. This might be due to data collection timing that favors the availability of geophytes especially the wet season. This result indicates that the researcher treating the modification of Raunkiaer (1934) system of life form classification by Mueller-Dombois and Ellenberg (1974) to include the data during favorable conditions. Geophytes have well protected new growing buds in the ground and they are characteristic of Mediterranean type of climate (Shimwell, 1971). It is not surprising to come with very poor representation of Phanerophytes in Afro-alpine area which is avery adverse climatic conditions that do not support this type of life form. Phanerophytes are indicators of favorable conditions according to Raunkiaer (1934). This result is supported by Ghelichnia (2014) in the study of Flora and vegetation of Mount Damavand in Iran.

Normal Biological Spectrum

The chi-square test confirmed a significant difference ($\chi 2$ = 129.85, $p < 0.001$) between the observed Abune-Yosef community conservation area and Raunkiaer's normal spectrum. Chamaephytes exhibited marked deviation (36%).From normal Raunkiaer's spectrum based on individual values (Table 1). Mendes *et al.* (2010) reported significant difference between Raunkiaer's spectrum and flora of Brazil that showed high proportion of Phanerophyte. Another study from Pakistan reported Therophytes with the highest individual values (34%) obtained from Chi-square (X^2) test and showed high deviation from the Raunkiaer's spectrum (Khan and Khan, 2017). These two findings support strongly results from the present study in which Chamaephytes showed significant deviation from the Raunkiaers spectrum. The biological spectrum of Mount Abune-Yosef reflects high altitudinal zone and found in the tropics, they are characterized by tropical Mountains so Chamae-Therophytic climate may be due to the effect of altitude in tropical climate and anthropogenic disturbance.

Floristic contribution

With regard to floristic contribution Asteraceae are represented by all the five major life forms, e.g. *Bidens macroptera* (Therophyte), *Helichrysum splendidum* (Chamaephytic), *Euryops pinifolius* (Phanerophytic), *Dianthoseris schimperi* (Geophytic) and *Anthemis tigreensis* (Hemicryptophytic). As its dominancy indicates the family Asteraceae develops different survival strategy to cope with different environmental conditions. Next to Asteraceae, Caryophyllaceae with geophytic and Therophytic life form (e.g. *Stellaria media*-Therophyte and *Silene macrosolen*- Geophyte), Scrophulariaceae represented by Chamaephytic, Hemicryptophytic and Therophytic. Lamiaceae represented by Chamaephytic, and Hemicryptophytic life form (see Appendix 1).The endemic plant species that are represented in all life forms accounts for 17.76% of the total 107 taxa, which comparatively higher than the 10% endemism of the Ethiopian Flora. This indicates that the Abune -Yosef community conservation area is one of the richest sites in the distribution of endemic species of plants in Ethiopia. However, according to the IUCN Red List Categories (Vivero *et al.*, 2005); some of the endemic taxa such as *Inula confertiflora* and *Satureja punctate* are found to be on the verge of threatened while *Euryops pinifolius* is vulnerable to extinction. On the other hand *Solanecio gigas* is under the list concerned species categories in the mountain.

The Effect of Altitude on Life form Distribution

The biological spectrum obtained in the present study is a reflection of existing environmental conditions. Diversity and distribution of life forms is usually correlated with climatic heterogeneity (Cowling *et al.*, 1994) decreasing with increasing altitude (Montana and Valientebanuet, 1998, Pavon *et al.*, 2000). The life form that ended at the lowest elevation was the phanerophytes which become rare relative to elevation. Therophytes also declined gradually. Geophyte and Hemicryptophytes took a lower share as well.

In Mount Abune-Yosef, Chamaephytes have a tendency to increase at higher altitudes. The results from Klimes (2003) confirm that Chamaephytes show an increasing trend towards higher altitudes. The work of Muhammad (2012) concluded that

Chamaephytes are generally the most common life forms in high altitudes. Hussain *et al.* (1997a) reported that in Girbanar Hills (Pakistan), Chamaephytes increased from lower altitude to higher altitude. They are generally the most common life form in high altitude.

Conclusion

According to the biological spectrum, the flora of the Mount Abune-Yosef is described as the Chamae-Therophytic. Chamaephytes are characteristics of the colder and high altitude or more prominent Afro-alpine and sub-Afro-alpine zones. The ecological condition of the Afro-alpine area is highly influenced by anthropogenic disturbance like farming up to highest altitude, road construction, grazing, firewood collection, grass cutting and proximity of settlement to the higher altitude. The contribution of Hemicryptophytes was relatively less due to the absence of sufficient soil moisture to support the growth of this life form. Geophytes were exceeding the expected normal life form spectrum. From all life forms, Phanerophytes had poor representation due to very adverse climatic conditions in Afro-alpine area.

The chi-square test confirmed a significant difference ($X^2 = 129.85$, $p < 0.001$) between the observed Mount Abune-Yosef community conservation areas and Raunkiaer's normal spectrum. Chamaephytes exhibited a marked deviation (36%). The family Asteraceae is the dominant family represented with all five major life form types that indicates adaptation dynamics of the family.

Diversity and distribution of life forms is usually correlated with climatic heterogeneity and decreasing with increasing altitude. Chamaephytes have increasing tendency towards higher altitude. Finally, the study of life form compositions can relate changes in biodiversity to changes in environment. Life form studies could serve as an indicator for environmental changes by throwing light on whether changes are caused by climate change or by change in land uses. By monitoring changes in life form composition, we should be able to monitor the effects of climate change and other environmental changes at very different scales and different vegetation types especially the fragile Afro-alpine environment like Abune-Yosef Mountain.

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